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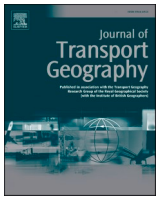

Perceived accessibility: A literature review

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ABSTRACT

The integration of accessibility measures into transport planning has become prominent in many regions. However, accessibility evaluation is hampered by not having a comprehensive view on how accessibility is perceived by various population groups and how it impacts their choices given certain transport and land use configurations. Recently, studies have emerged attempting to measure perceived accessibility and understand its determinants and how it relates to various aspects such as travel behaviour and social inclusion using a variety of definitions and methods. In this paper, we review the empirical research on perceived accessibility, aiming to provide structure to future research on this topic. Based on 45 studies discussing perceived accessibility, we find that the concept is often ambiguously defined, and that measures lack robust validation regarding capturing the core aspects of accessibility and perception at the individual level. Moreover, results regarding the links between socioeconomic characteristics and perceived accessibility lack consistency and validity. The relationship between perceived accessibility and travel-related outcomes remains underexplored and requires further investigation, including indirect and bidirectional effects. Based on this literature review and earlier conceptualizations, we construct an empirical research framework that paves the way for future research by proposing relationships between perceived accessibility, calculated accessibility, travel behaviour, residential choice, as well as individual sociodemographic characteristics and attitudes. Understanding how various population groups perceive accessibility is essential for developing more accurate land use and transport measures that impact their behaviour and well-being.

1. Introduction

For the largest part of the 20th century, transport planning prioritized mobility as the key to enhancing access to social and economic opportunities, causing continuous growth in road infrastructures (Downs, 2004). In recent years, the call for sustainability and the development of equitable living spaces has shed light on the social and environmental downsides of this planning approach (Banister, 2012). In turn, there has been a significant shift in thinking within the transport planning field, moving away from merely emphasizing the movement of vehicles (mobility) towards explicitly prioritizing the provision of people with access to spatially and temporally dispersed opportunities (accessibility) (Dalvi and Martin, 1976; Handy, 2023; Miller, 2018).

Calculated measures of accessibility, which are based on spatial data, have shown promise as social indicators and equity evaluators (Foth et al., 2013; Wachs and Kumagai, 1973), with many aspects of equity and social exclusion yet to be studied and addressed (van Wee and Geurs, 2011). To address these aspects, individual-centered theoretical approaches, such as the Capability Approach, have been proposed to explore how accessibility is understood and utilized by people with diverse backgrounds and needs, stressing the importance of individual perceptions (Vecchio and Martens, 2021). In this light, the notion of perceived accessibility has been gaining attention in the literature as it accounts for individual perceptions, subjective experiences, and personal characteristics that mediate the relationship between land use and transport system configurations and how people experience them (Lättman et al., 2016a; Pot et al., 2021; van Wee, 2016). Recently, Pot et al. (2021) laid the theoretical foundation for perceived accessibility, linking it to calculated measures and highlighting the potential mismatches that might exist between them.

Accessibility is typically analyzed at a local (mesoscale) or regional (macroscale) spatial level (Handy, 1992). Local accessibility presents

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the amount and variety of nearby amenities accessible in a neighborhood through active travel modes (i.e., walking and cycling) (Forsyth and Krizek, 2010), while regional accessibility is more concerned with reaching destinations by passenger transport (i.e., car and public transit) (Geurs and van Wee, 2004). The key distinction between these two levels is not just the mode of travel but also the factors that influence accessibility levels. While the density, diversity, and design of the built environment play a major role in shaping local accessibility and impacting active travel (Cervero and Kockelman, 1997), regional accessibility depends on the interplay between transport networks and land use configurations such as the spatial distribution of job opportunities in a region (Geurs and van Eck, 2001; Geurs and van Wee, 2004; Miller, 2018). Perceived walkability (i.e., perceived accessibility for walking) was recently reviewed by De Vos et al. (2023); meanwhile, no comprehensive literature review has specifically examined perceived accessibility at the regional scale. This study will focus on perceived regional accessibility; therefore, any reference to accessibility throughout the manuscript will pertain to the regional level unless the local level is explicitly mentioned.

As perceived accessibility is an emerging topic, a growing number of studies are aiming to define it, quantify it, and explore its determinants and impacts. This study reviews 45 articles published between 2016 and early 2025 that have empirically examined perceived regional accessibility, highlighting the state of research concerning its definitions, measurements, determinants, and outcomes. Based on this review, we propose a conceptual framework for perceived accessibility that builds on previously examined relationships while introducing potential ones to be explored in future research. This framework helps identify research gaps and guide a research agenda for advancing the study of perceived accessibility in the field of urban planning and transportation. Understanding the current state of knowledge about perceived accessibility and its effect is crucial for researchers and transport professionals. For researchers, this study provides a comprehensive overview of the works exploring the topic, offering insights into potential areas of research. For policymakers and transport planners, perceived accessibility research can inform strategies that enhance equitable access to opportunities and encourage sustainable travel behaviour.

2. Background

The term "perceived accessibility" combines the notions of accessibility and perceptions. This section begins by separately discussing the definitions and key aspects of both concepts. Then, it delves into the idea of perceived accessibility as an amalgamation of these notions, examining how it has been discussed in prior research and how it can be defined.

2.1. Accessibility

Accessibility is regarded as a function of land use and transport systems, representing the ability of different individuals—each with unique needs and circumstances— to reach destinations by different transport modes, while also considering temporal components such as time of travel, travel time, and the timing of available opportunities (Dalvi and Martin, 1976; Handy, 1992; Hansen, 1959; Levinson and Wu, 2020). In his seminal work, which is considered a pivot to the concept until this day, Hansen (1959) defined accessibility as "the potential of opportunities for interaction" (p.73). In that sense, accessibility indicates how one can overcome distance barriers to reach spatial opportunities (e.g. jobs) distributed across space using different transport systems. The heterogeneity in individual needs and abilities, combined with the complexity and variability of transport and land use components has led to accessibility being described as "a slippery notion" (Gould, 1969, p. 64). This description has been used to stress how researchers and practitioners define it based on their objectives (Morris et al., 1979).

Wachs and Kumagai (1973) define accessibility as "the ease with which citizens may reach a variety of opportunities for employment and services" (p.437). However, they add that "such a concept is too vague and devoid of goal orientation" (p.441). They clarify that accessibility as a measurement is about the number or density of travel opportunities within certain time distances. Many subsequent researchers described measures of accessibility with the word "ease", referencing the work of Wachs and Kumagai. Morris et al. (1979), Handy and Niemeier (1997), Levinson and Wu (2020), and El-Geneidy and Levinson (2022) describe accessibility as the ease with which activities can be reached using a particular transport system.

Accessibility constitutes four main components: space (land use), movement (transport), time (temporal component), and subject (individuals) (Geurs and van Wee, 2004). Based on the interaction between these components, accessibility measures can be categorized and viewed from various perspectives embedded in different economic, transport, and social theories (El-Geneidy and Levinson, 2006; Geurs and van Wee, 2004; Horner, 2004). Place-based measures (also referred to as geographical and location-based) are typically used at the aggregate/regional level and are the most used in practice (El-Geneidy and Levinson, 2022). They focus on the spatial distribution of activities and represent the levels of attractiveness of locations relative to one another (Horner, 2004). They mainly focus on the transport (travel time and costs) and land use (amount and spatial distribution of activities) components, with possibilities of integrating the spatial component (e.g., the daily fluctuations in public transit services) or an aggregate level of the individual component (e.g. by income groups). Their aggregate characteristic makes them easy to use as a planning tool that helps understand travel behaviour such as mode share and development impacts on the regional level (El-Geneidy and Levinson, 2022).

Two of the most common place-based measures in the literature are cumulative opportunities and gravity-based measures (Miller, 2018). In cumulative opportunities measures, all the opportunities (destinations) available within a predefined travel time threshold are weighted equally while gravity-based accessibility weighs opportunities based on the travel time necessary to reach them (Geurs and van Wee, 2004). The latter method allows for the inclusion of opportunities that could be discarded in the cumulative measures but requires more data and is more challenging to compute, interpret, and communicate. Comparisons show high correlation between the two methods in North America (El-Geneidy and Levinson, 2006; Giannotti et al., 2021; Kapatsila et al., 2023; Palacios and El-Geneidy, 2022), suggesting that cumulative opportunities measures are adequate in presenting the built environment with easier interpretation and communication to the public and policymakers (El-Geneidy and Levinson, 2022).

People-based measures of accessibility focus on the space-time restrictions of individuals, at the disaggregate level, using time geography as a theoretical framework (Ferreira and Batey, 2007; Geurs and van Wee, 2004; Miller, 2005). This approach challenges the notion that strong geographical connections between individuals and activities always imply high levels of accessibility between them due to personal spatial and temporal constraints (Ferreira and Batey, 2007). This approach is more accurate in representing individual accessibility as it accounts for the heterogeneity related to personal constraints (Fransen et al., 2018; Morris et al., 1979; Neutens et al., 2012; Neutens et al., 2010; Schwanen and Dijst, 2003). Despite this approach being challenging to operationalize at a regional level as it requires detailed data for each individual, it can be used to provide deeper insights into individuals' travel behaviour, activity participation, and well-being.

In many cases, the representation of the built environment through numbers and calculations, such as in these measures of accessibility, is referred to as an objective measure (Gim, 2011; Ma and Cao, 2019; McCormack et al., 2007; McGinn et al., 2007; Pacione, 1982; Scott et al., 2007). However, as accessibility is defined as the 'ease' by which opportunities can be reached, accessibility is always conditioned by subjective perceptions (Pot et al., 2021). Consequently, objectivity in

measurement does not exist and indicators based on spatial data using pre-set impedance thresholds will always be prone to the subjectivity of the researcher setting these thresholds (Muckler and Seven, 1992). With the rising interest in other aspects of accessibility (i.e., perceived accessibility), it has been lately proposed to label "objective" measures as "calculated" ones to avoid the subjective bias in objectivity (Pot et al., 2021; Ryan and Pereira, 2021). Nevertheless, we acknowledge that calculated measures inevitably involve a certain degree of subjectivity.

2.2. Perception

Building a perception, mental representation, of the world is a complicated process that is subjected to a wide array of influencers. While people physically live in a tangible real environment, they mentally live in and act based on a cognitive one that is filtered according to each individual's perceptual receptors and made sense of based on their attitudes and beliefs (Downs, 1970; Holloway and Hubbard, 2001), sociodemographic characteristics (Burnett, 1978; Lee, 1970; Nasar et al., 1985; Popp et al., 2004), lived experiences (Vernon, 1970), and vicarious experiences (Drakulich, 2015), among other factors. Individuals' interactions with the world are mediated by mental processes and cognitive representations of their surrounding environments (Gold, 1980; Lynch, 1960; Ma and Cao, 2019). This cognitive image of the world is filled with personalized warning signs and green lights, guiding their thoughts, decisions, and actions (Mehrabian and Russell, 1974).

The knowledge of the built environment is shaped through spatial information, which has locational and attributive components (Gold, 1980). The locational component includes declarative, relational, and procedural knowledge (Golledge and Stimson, 1997). This knowledge—of the absolute positions of places, the spatial relations between different places, and how one can move between them—forms the basis for wayfinding and route learning (Golledge et al., 2000). The attributive information includes characteristics of particular spaces themselves and against one another (Gold, 1980). This type of information plays a role in the decision-making process. Research has shown that spatial knowledge is not enhanced through advanced information technologies (Ahmadpoor and Heath, 2018); nevertheless, they play a major role in navigation and give temporary attributive (where to go) and procedural (how to get there) information that would influence behaviour. For example, one can decide to walk instead of taking public transit if they find that walking will not take any longer through using a navigation software.

2.3. Perceived accessibility

Combining transport and land use system configurations and perceptions as a mediator between the physical and the cognitive environment results in the concept of perceived accessibility. The first accounts of this concept are attributed to Morris et al. (1979) when they stated that perceived accessibility is the real determinant of behaviour and that it will be at variance with measured indicators of accessibility. Linking perceived accessibility to behaviour, Ben-Akiva and Lerman (1979) defined accessibility as "some composite measure which describes the characteristics of a group of travel alternatives as they are perceived by a particular individual" (p.654). In the following years, most research focused on the operationalization of measured accessibility in practice with pre-set assumptions on perceptions; therefore, it was more concerned with improving and validating the calculated measures as they provided more concrete results and a basis for comparison between different scenarios and regions.

Decades later, Ferreira and Batey (2007) presented a theoretical approach for accessibility as the perceptions-aware approach. This approach connects accessibility-based behaviour to personal spatial knowledge and experience in addition to time-space restrictions (Miller, 1991). Cascetta et al. (2016) emphasized that the notion of "availability" of opportunities when considering accessibility is based on two components: a spatiotemporal component, based on calculation; and a behavioural component, based on perception. In their definition, an available opportunity is not just one that is included within some assumed spatiotemporal constraint, but one that is also perceived by that individual as a potential alternative that satisfies their needs. In light of recent calls for equitable planning that enables individuals, there has been a recognized necessity for a deeper understanding of how people perceive accessibility from their subjective point of view (Curl et al., 2011; van Wee, 2016; Vecchio and Martens, 2021).

3. Methods

There is a consensus in the literature that perceived accessibility remains underexplored on both the local and regional scales (Curl, 2018; De Vos et al., 2023; Pot et al., 2021; van Wee, 2022). As a recent literature review by De Vos et al. (2023) focuses on the local scale of perceived accessibility (i.e., perceived walkability), this review focuses on the studies that examined perceived regional accessibility. To identify these studies, we searched three academic databases — Web of Science, SCOPUS, and TRID. We then screened the titles and abstracts of the resulting articles to identify the ones that mention perceived accessibility and performed a full-text assessment to retain the studies that measure and discuss regional perceived accessibility (Fig. 1).

In the identification step, we searched the three databases using the following keywords: ("perceived accessibility" or "perception of accessibility" or "self-reported accessibility") and ("regional" or "transportation" or "transport" or "transit" or "car" or "private vehicle"). This search displays studies that have both a term from the first pair of parentheses and a term from the second one in their title, abstract, or keywords. We only searched for journal articles written in English. The initial databases search was conducted on August 8th, 2024, resulting a total of 289 papers from the three databases. During the manuscript revision, the database searches were updated to include articles published during the review period. The final inquiry resulted in a total of 345 studies: 144 studies in Web of Science, 126 in SCOPUS, and 75 in TRID, with February 11th 2025 as the final search date. This approach was supported by snowballing from the key papers that discuss perceived accessibility from a regional perspective to ensure a comprehensive view of the literature. This led to the inclusion of 11 additional papers into the pool of studies for review. From the final database searches and snowballing, 356 articles were identified for review, as illustrated in Fig. 1.

Following the removal of duplicates and an initial scan of the titles and abstracts of the 356 articles, 65 empirical full (peer-reviewed) journal articles were selected for deeper analysis. During the initial scan, it was observed that most studies stemming from the snowballing method—referenced in the context of perceived accessibility in transport—focused on distance-based spatial access, with no connection to

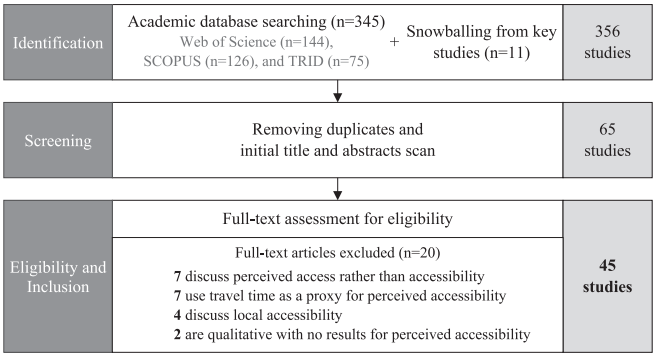

Fig. 1. PRISMA flow diagram for identifying studies to be included in the analysis.

the concept of accessibility (Baier et al., 2020; Macintyre et al., 2008; Scott et al., 2007; Wang et al., 2015). These studies focus on the concept of 'access' by measuring the distance to the nearest opportunity (e.g., healthcare facility or park) or the number of opportunities within a certain distance buffer without considering travel time by different transport modes. While distance-based measures can serve as a proxy for travel times at the local level—where a general walking or cycling speed can be reasonably estimated—this approach is insufficient at the regional level, where street networks and transit service significantly impact travel times. Since this review focuses on regional accessibility (mostly measured by the number of opportunities one can reach within a given travel time by car or public transit), these distance-based access studies were excluded as they are out of the scope of this research.

Upon deeper examination, only 45 articles were retained for full analysis of measures and results. Eleven of these papers were published during the reviewing period of the manuscript in late 2024 and early 2025, signifying the rapid development and emerging nature of the topic. The filtering process excluded studies that investigated access, travel time, local accessibility, or employed qualitative methodologies. Seven studies used the term perceived accessibility, but they rather discussed perceived access. These studies were concerned with walking distance, conditions, or route attributes to certain destinations, such as public transport stations (Cheng and Chen, 2015; Márquez et al., 2019; Ryan et al., 2016; Shao et al., 2022; Wong, 2018) or health services (Bihin et al., 2022; Fone et al., 2006), rather than on accessibility as a measure of opportunities reachable within a certain travel time.

Seven studies were disregarded from the final list as they mainly focused on perceived travel time as a proxy for perceived accessibility (Curl, 2018; Curl et al., 2015; Liu et al., 2018; Susilo and Liu, 2017; Tiznado-Aitken et al., 2020; Tiznado-Aitken et al., 2021; Wang et al., 2024). Self-reported travel times (e.g. Curl, 2018; Curl et al., 2015) oversimplifies the concept of accessibility, effectively reflecting only one component of accessibility. In this case, the revealed mismatches between the "objective" and "perceived" measures rather present the individual's perception of mobility (Geurs and van Wee, 2004). Therefore, perceived travel time, even though it considers personal factors, does not reflect an individual's perception of the opportunities provided by the built environment. Likewise, proposing a generalized travel time measure that accounts for the subjective valuation of access, waiting and in-vehicle time, in addition to comfort and transfers (Tiznado-Aitken et al., 2021), does not consider the perception of accessibility to the wide range of desired opportunities (activities).

Four more studies were excluded as they discussed perceived accessibility at the local scale (neighborhood level) rather than the regional scale which is the focus of this review (Hu and Ettema, 2023; Ma et al., 2025; Richard et al., 2009; Scheepers et al., 2016). Some of these studies disregarded public transport as a means of transport as the authors found that it would be difficult for participants to correctly evaluate destination accessibility for that mode. Finally, two studies were omitted from the analysis because they briefly mention the concept of perceived accessibility in their discussions but do not clearly define the concept, explain its measurement, discuss its implications, or compare it with spatial measurements (Oviedo et al., 2024; Pot et al., 2020).

4. Findings

Table 1 summarizes the 45 studies we retained for analysis as they address aspects of perceived regional accessibility. Notably, 18 of these studies were published in 2024 and 2025, highlighting the topic's recent relevance. With the scarcity of literature due to its novelty, we retained all possible studies regardless of paper or journal quality. While all journals are peer-reviewed, the peer-review process may considerably vary by journal. We carefully examine the papers chosen and report their results with caution, acknowledging that they can be incomplete or potentially misleading. Based on the aspects discussed in the papers, we extract four topics that we present in this section: definitions, measures, and determinants and impacts of perceived accessibility, as well as the mismatch between calculated and perceived accessibility measures.

4.1. Definitions of perceived accessibility

While the notion of perception in accessibility has been mentioned in the literature since the late 1970s (Ben-Akiva and Lerman, 1979; Morris et al., 1979), the introduction of the Perceived Accessibility Scale (PAC) by Lättman et al. (2016b) sets a starting point for the recent empirical research done on perceived regional accessibility. The developers of this tool approach perceived accessibility as an outcome of the transport and land use system, defining it "how easy it is to live a satisfactory life using the transport system" in a number of their papers (Friman et al., 2020b; Lättman et al., 2016a; Olsson et al., 2021). Incorporating "transport system" in this definition is crucial as it helps differentiate the level of accessibility in question, whether by local (De Vos et al., 2023; van der Vlugt et al., 2022) or regional modes. Relatedly, Sukhov et al. (2023) defines perceived accessibility as "the degree of ease with which individuals can live their lives using a transportation system." This definition is also focused on the outcome of a transportation system and how it connects to someone's ease of living.

However, incorporating a satisfactory life into definitions of perceived accessibility may expand the concept beyond its intended scope, which is an overall individual evaluation of access to desired opportunities. Approaching perceived accessibility should be limited to the benefits derived from the transport and land use system, serving as a tool to evaluate the system's performance based on its impact on individuals' evaluation of access to opportunities. Despite transport playing a part in life satisfaction (De Vos and Witlox, 2017), it is not the most important determinant (Pavot and Diener, 1993). Positive perceptions of accessibility do not necessarily relate to a satisfactory life and may not even relate to satisfaction with travel. Such definitions overreaches and disconnects perceived accessibility from the concept of accessibility which focuses on reaching destinations and potentially interacting with different opportunities.

Taking a different perspective, the definition of perceived accessibility formulated by Pot et al. (2021) describes it as the "perceived potential to participate in spatially dispersed opportunities" (p.2). This descriptive definition emphasizes the perception of a quantity of opportunities available through spatial reach on which individuals make decisions, without reference to an eventual social outcome in terms of behaviour, participation or satisfaction. Consequently, this measure is neutral and particularly suited for conceptualizing perceived accessibility but less suited for deriving indicators to empirically evaluate the benefits of transport and land use systems as experienced by people.

When empirically evaluating the outcomes of the transport system, it is crucial to distinguish the definition of perceived accessibility from the outcomes, such as its influence on life satisfaction. We argue that previous definitions of perceived accessibility tend to overreach and that a more focused definition for evaluating the benefits of transport and land use system configurations is needed— one that remains grounded in the core concept of accessibility itself, without extending into life satisfaction or other well-being domains.

4.2. Measures of perceived accessibility

The Perceived Accessibility Scale (PAC) was the most common measure for perceived accessibility, directly used by 23 out of the 45 studies and adapted to a different phrasing by four. Based on key works on accessibility and travel satisfaction research, this measure was originally developed by Lättman et al. (2016b) as four questions that assess the transport system's impact on the ability, ease, and satisfaction of participation in activities, and the ability to live as one wants. This measure was further developed by the same authors two years later (Lättman et al., 2018). While both versions of the PAC are mode-specific,

Table 1
Overview of 45 studies about perceived accessibility in chronological order.

Study	Data (N and location)	Perceived Accessibility measure	Main Methods	Main contribution(s)/Result(s)
Lättman et al. (2016b)	237 (Study 1), 246 (Study 2, W1), and 259 (Study 2 W2) participants in Karlstad, Sweden	PAC (7-point Likert scale on 4 statements)	Exploratory and Confirmatory factor analysis (EFA & CFA)	Development and validation of the Perceived Accessibility Scale (PAC)
Lättman et al. (2016a)	750 bus riders in Karlstad, Sweden	PAC (public transport)	Conditional process model and cluster analysis	Perceived public transit service quality, perceived safety, and frequency of use positively influence perceived accessibility.
Lättman et al. (2018)	2711 residents in Malmö, Sweden	PAC (main mode)	EFA and One sample *t*-tests	- Modifications to the original PAC - Calculated and perceived measures of accessibility by sustainable transport modes are misaligned.
van der Vlugt et al. (2019)	286 residents in Nottingham, UK (First study case only)	5-point Likert scale on 3 statements	Multivariate regression	- Socio-demographic and attitudinal factors impact perceived accessibility. - Favourable attitude towards public transport positively impacts perception of accessibility.
Thronicker and Klinger (2019)	758 participants in Leipzig, Germany	5-point Likert scale on 6 statements	Logit model	Higher perception of accessibility by sustainable modes increases the chance of being interested in a mobility package.
Lättman et al. (2019)	2950 older adults in Stockholm, Oslo, Helsinki, Copenhagen, and Bergen	PAC (main mode)	PLS-SEM	Positive perceived accessibility contributes to travel satisfaction and overall life satisfaction.
Lättman et al. (2020)	2711 participants in Malmö, Sweden	PAC (main mode) and PAC (if car is no longer an option)	T-tests	Perceived accessibility decreases for car users when they are limited to sustainable modes for their daily travel.
Friman et al. (2020a)	122 carpoolers in Sweden	PAC (carpooling)	Multiple linear hierarchical regression	- Simplicity as a motive and commuting as a purpose increase perceived accessibility by carpooling. - Perceived accessibility by carpooling increases in higher density areas.
Friman et al. (2020b)	4944 public transport users in Stockholm, Oslo, Helsinki, Copenhagen, and Bergen	PAC (main mode)	PLS-SEM	- Better service quality has a positive impact on perceived accessibility. - Frequent transit users have lower perception of accessibility than less frequent ones.
Warner et al. (2021)	306 participants in Stockholm, Sweden	PAC (main mode)	One-way ANOVA	For public transport, people in the motivation stage of the transtheoretical model (TTM) have a more positive perception of accessibility than those in the volitional stage.
Aoustin and Levinson (2021)	197 participants in Sydney, Australia	Perception of percentage of accessible jobs in 30 mins Capability to walk, cycle, use car, or use public transport to carry out all everyday activities (Dichotomous)	Means comparison	Participants mostly overestimated the walking, cycling, and public transport access.
Ryan and Pereira (2021)	1149 older adults in Gothenburg, Malmo, and Stockholm		Multinomial logit	Conventional accessibility measures tend to overestimate accessibility levels, especially for cycling when compared to public transit.
Al-Rashid et al. (2021)	243 older women in Lahore, Pakistan	PAC (public transport)	PLS-SEM	- Higher levels of perceived accessibility increase social inclusion. - Perceived social norms and perceived neighborhood social environment have a positive effect on perceived accessibility.
Olsson et al. (2021)	1376 participants in Sweden (major city areas and other areas)	PAC (public transport)	Linear multiple regressions	Travel behaviour, household, and personal characteristics are associated to perceived accessibility.
Liu et al. (2021)	569 participants in Kunming, China	6-point Likert scale on 3 statements	Cross-lagged panel models	The ease of using smartphone-based services influences perceptions of accessibility and transport equity.
Lukina et al. (2021)	2275 participants in Moscow	PAC (main mode) – 4-point Likert instead of 7-point	One-way ANOVA	Perceived accessibility differs based on travel behaviour, residential area, and sociodemographic factors.
Tanimoto and Hanibuchi (2021)	1474 participants in Sendai, Japan	5-point Likert scale on 4 statements to measure sense of accessibility	Ordered logit	- Good self-rated health is associated with higher sense of accessibility. - Dense, urbanized environments increase the sense of accessibility.
Sheng and Zhang (2022)	341 participants in Hangzhou, China	PAC (public transport)	PLS-SEM	Perceived accessibility by public transport positively affects behavioural intention and actual behaviour in using public transport.
El Murr et al. (2023)	873 participants in Montreal, Canada	5-point Likert scale on one statement	Ordered logit	There is a misalignment between the number of parks accessible and the self-reported accessibility (negative relationship). The quality index for parks and the self-reported accessibility are aligned (positive relationship).
Wolday and Böcker (2023)	858 panel participants in Oslo, Norway	PAC (main mode)	SEM	Residential location mediated the impact of the COVID-19 restrictions on perceived accessibility by public transport.
Pot et al. (2023a)	3378 participants in the Netherlands	PAC (main mode)	Propensity score matching (PSM)/ average treatment effect (ATE)	Perceived accessibility is spatially more evenly distributed between than the number of opportunities due to diminishing returns and residential self-selection.

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Table 1 (*continued*)

Study	Data (N and location)	Perceived Accessibility measure	Main Methods	Main contribution(s)/Result(s)
Liu et al. (2023)	536 tourists in Mount Yandang Scenic Area, China	6-point Likert scale on 4 statements to measure perceived destination accessibility	PSM/ATE	Perceived destination accessibility and perceived transport equity significantly increased due to the free within-destination tourist bus scheme.
Al-Rashid et al. (2023)	384 older adults in Lahore, Pakistan	PAC (public transport)	PLS-SEM	Perceived accessibility moderates the effect of social and personal norms on social exclusion.
Andersson et al. (2023)	52 employees in Stockholm, Sweden	PAC (main mode)	Mixed ANOVA	- With increased use of public transport, the perceived accessibility decreased, but the self-reported life quality increased. - Free public transport (PT) card intervention had no effect on perceived accessibility.
Pot et al. (2023b)	2227 participants in rural areas in the Netherlands	PAC (main mode)	OLS and Quantile regression	- Perceived accessibility correlates poorly with accessibility calculated from spatial data and rather depends on individual conversion factors. - Lowest levels of perceived accessibility in rural areas are related to a combination of social disadvantages.
Sukhov et al. (2023)	117 older adults in Stockholm, Oslo, Helsinki, Copenhagen, and Bergen	PAC (main mode)	PLS-SEM, NCA, and fsQCA	Comfort is a significant determinant for perceived accessibility for older adults.
Friman and Olsson (2023)	1041 participants in Sweden	PAC (main mode)	PLS-SEM	- A stronger sense of travel autonomy is related to higher perceived accessibility. - Perceived accessibility positively impacts life satisfaction.
Fu et al. (2024)	1009 participants in Rotterdam and Utrecht, the Netherlands	5-point Likert scale on 8 statements for perceived transport adequacy and 5 statements for perceived accessibility	Multiple linear regressions	- Multimodality has no significant effect on perceived transport-related achievement (mentioned as perceived accessibility in the other studies). - Bus access, ease of driving, and perception of good quality of public transport have a positive effect on perceived achievement.
Pot et al. (2024)	3378 participants in the Netherlands	PAC (main mode)	Multinomial logit	Low activity participation is not always indicative of involuntarily social exclusion, as it often nonetheless coincides with high perceived accessibility, particularly in cities.
Vafeiadis and Elldér (2024b)	1423 participants in Gothenburg, Sweden	5-point Likert scale on at least two statements related to transport mode (maximum four)	Multinomial logit	Mismatch between calculated and perceived accessibility for grocery shopping is more common for car travel, with underestimation of calculated measures.
Watthanaklang et al. (2024)	400 public transport users in Nakhon Ratchasima Province, Thailand.	PAC (public transport)	SEM	- Public transport service quality has a positive effect on perceived accessibility. - Perceived accessibility has a direct positive effect on the intention to use public transport.
Blandin et al. (2024)	298 participants in Santiago de Chile	5-point Likert scale on four psychometrics indicators	ICLV and logit (MNL) models	Perceived accessibility is determined by the perceived cost of travelling, perceived quality of the environment and/or availability of different transport modes.
Vafeiadis and Elldér (2024a)	1534 participants in the Gothenburg Region, Sweden	5-point Likert scale on 16 statements	Ordinal regression models	- Transportation resources, habits and attitudes have the strongest effect on perceived accessibility. - Car access reduces perceived accessibility for all other modes.
Vafeiadis (2024)	1423 participants in the Gothenburg Region, Sweden	5-scale Likert scale on 20 statements	Bivariate and Semi-partial correlation	There is a significant moderate relationship between accessibility indicators and perceived accessibility. It is positive for transit users, cyclists, and pedestrians, however, negative for car users.
Chau et al. (2024a)	156 participants in the City of Wyndham, Australia	PAC (main mode) and PAC (public transport)	Principal Component Analysis (PCA) and Comparison of means	Perceived accessibility is higher for current travel modes compared to a scenario where only public transport is available.
Kim (2024)	200 older adults in the Republic of Korea	5-point Likert scale on 3 statements	Partial Least Squares (PLS) Bootstrapping	Perceived accessibility by public transport positively influences life satisfaction for older adults.
Chau et al. (2024b)	156 participants in the City of Wyndham, Australia	PAC (public transport)	PLS-SEM	Perceived safety has a positive influence on perceived accessibility.
Zhu et al. (2024)	664 affordable housing residents and 828 commercial housing residents in Nanjing, China	7-point Likert scale on 6 statements	SEM	- Public transport service levels and transport affordability positively impact perceived accessibility. - Perceived accessibility positively impacts perceived housing equity and transport equity.
Parga et al. (2024)	524 respondents in Scarborough, Toronto, Canada	2 binary statements	Ordinal logistic regressions	Perceived accessibility is positively associated to self-rated health.
Hagen (2025)	387, 446, 311, and 522 participants in Arendal, Kongsberg, Lillehammer, and Tønsberg, respectively, in Norway.	5-point Likert scale on one statement	Cross-tabulation	- Perceived accessibility correlates with frequency of city center visits. - Negative perceptions about traffic and parking correlate with lower perceived accessibility.
Mehdizadeh and Kroesen (2025)	4945 panel participants (from two waves) in the Netherlands	3-point Likert scale on 3 statements	Cross-lagged panel model (CLPM)	Travel behaviour has a larger impact on perceived accessibility than the reverse effect.

(*continued on next page*)

Table 1 (*continued*)

Study	Data (N and location)	Perceived Accessibility measure	Main Methods	Main contribution(s)/Result(s)
Nguyen-Phuoc et al. (2025)	535 participants in Hanoi, Vietnam	7-point Likert scale on 3 statements	PLS-SEM	Perceived accessibility by an urban train system positively influences the intention to switch to it from other modes.
Moleman and Kroesen (2025)	20,020 respondents in the Netherlands	5-point Likert scale on 7 statements	Latent class analysis	Only a small portion of society perceives lower accessibility.
De Vos et al. (2025)	2593 students and staff members at UCL, London, UK	5-point Likert scale on 2 statements	One-way ANOVAs with post-hoc and ordered regressions	Perceived accessibility to campus—both in general and by public transit—is positively influenced by ease-of-travel elements, especially travel skills.
Negm and El-Geneidy (2025)	2985 participants in Montreal, Canada	4-point Likert scale on 1 statement	Linear regression	Perceived accessibility by public transit positively impacts weekly public transit mode share.

the 2016 version directly represents one specific mode at a time. With "X" being the transport mode in question, the four statements are as follows: (1) "It is easy to do (daily) activities with X", (2) "If X was my only mode of travel, I would be able to continue living the way I want", (3) "It is possible to do the activities I prefer with X", (4) "Access to my preferred activities is satisfying with X" (Lättman et al., 2016b). Each of these statements would be assessed on a 7-point Likert scale (ranging from I don't agree = 1 to I completely agree = 7). The modification in the updated version of the scale is the removal of the specific mode (X) part of the questions and replacing it with "Considering how I travel today" and using the present tense for the statements. In both versions, the perceived accessibility score is the mean value from the four assessments.

Using three datasets, Lättman et al. (2016b) conduct Cronbach's alpha analysis to confirm the correlation between the 4 scale items, then exploratory and confirmatory factor analyses to check whether the items are unidimensional. These methods, according to the authors aim to validate the scale by proving the matching psychometric properties of the four items which indicate high construct validity. Using three waves of data before and after altered service conditions by a public transport provider (with 259 participants as the largest N), the authors conclude that the PAC is sensitive to changes in service provision and, therefore, a valid instrument to assess accessibility.

This conclusion might be premature because the accessibility measures used do not describe conventionally calculated ones as the alterations mentioned do not include any frequency adjustments, but only an enhanced bus fleet with better amenities and improvement in the announcement function. Therefore, such alterations could affect how one perceives the system, but not change their calculated accessibility level. Another limitation of this study is the small and homogenous sample, with 90 % of participants being frequent bus users in all three datasets. Generalizing this scale without further validation could introduce significant bias, as the findings might not apply to different populations or contexts.

More generally, including the notion of satisfaction with life in the definition used to develop PAC could be problematic. Measuring perceptions of one's accessibility should be isolated from life satisfaction to avoid conflation with broader well-being concepts (see Section 4.1). The statements in the PAC tool include life satisfaction but, at the same time, are all specifically related to transport. Consequently, it is yet not clear to what extent the statements reflect general subjective well-being or are they are capturing accessibility-based utility. The PAC tool averages the score from four statements, which assumes equal weights, leading to loses in specificity, and ignores variability. Especially as each of the statements used capture a different aspect and level of an individual's perception, using the mean value for multiple statements could be a biased approach that leads to inaccurate interpretations. Another major limitation of the original study where the PAC tool was developed is the small and homogenous sample used, where 90 % of participants being frequent bus users in all three datasets. Generalizing this scale without further validation could introduce significant bias and incomplete results, as the findings might not apply to different populations or contexts.

Tanimoto and Hanibuchi (2021) used the term "sense of accessibility" to describe what is referred to as perceived accessibility in their article. They ask four questions with four possible combinations of reaching wanted and needed destinations with the usual mode of travel and without having the car as an option (e.g., I can do whatever I want even if I cannot use a car). The authors disconnect their measure from the literature with the claim that perceived accessibility in the literature is specific to one destination while "sense of accessibility" is not limited to specific destinations. However, when asking the sense of accessibility questions, they separate destinations by wanted and needed destinations. A problem that could arise from such an approach is that the differentiation between wanted and needed activities is ambiguous, as it is not clear how people differentiate between the two. This complicates judging whether accessibility needs and desires are sufficiently and equitably met.

In some instances, the measure used for perceived accessibility was technical such as asking participants to estimate the percentage of accessible jobs (Aoustin and Levinson, 2021). This approach can be misleading, as most people would not be able to intuitively estimate such a technical variable. Survey questions should be designed to be easily understood and to reflect daily life or expected situations. If questions are too difficult, respondents may drop out, or worse, provide random answers, which would compromise the study's findings. El Murr et al. (2023) used a rating of overall access to parks from home as a proxy for what they refer to as "self-reported accessibility", which is synonymous with perceived accessibility. In their study, where they compared the matching rate between perceived accessibility and various calculated measures, this approach was appropriate. As this question was not too specific or too broad, it allowed them to capture the role that park quality plays in the perception of accessibility. Ryan and Pereira (2021) relied on the notion of self-reported capability of using different modes to measure perceived accessibility. The question focused on the "possibility" of using different modes for daily activities, regardless of whether the participants choose to use them or not. This question was cross-referenced with another question asking about activities that participants are unable to conduct for some reason, as described in the study design (Ryan et al., 2019). However, this measure does not capture perceived accessibility using a specific mode to a particular destination. As a result, it risks a potential bias of assuming that the possibility of using a mode translates into positive perception of accessibility by that mode to destinations, which is often not the case. For example, just because walking is a possible mode of transport does not mean one considers it suitable for reaching any or all destinations. Blandin et al. (2024) consider perceived accessibility a latent variable and use four psychometric indicators to identify it. However, these indicators are neither destination nor mode specific, and they integrate the notion of satisfaction with movement which we discussed as a potential factor that could mislead results.

Fu et al. (2024) use the PAC to represent 'perceived travel-related achievement', which better suits that scale as it focuses on the outcomes of travel (e.g., life satisfaction) rather than the perception of accessibility. Meanwhile, they use the term perceived accessibility as a representation of whether one can easily reach five main destinations:

pharmacy or health center, supermarket or local shopping area, the hospital, friends and family's homes, and gym or hobby. The statements were rated on a five-point Likert scale, ranging from completely agree to completely disagree, allowing for nuances in the perception. While this measure is suitable to quantity perceived accessibility because it is destination-specific, it has a limitation of not-being mode specific. The authors ask whether one can reach the destinations with the transportation options available to them. This could be restricting policy relevance as it makes it harder to understand which areas need improvement, if any.

Many studies have adopted this destination-specific approach to measuring perceived accessibility (De Vos et al., 2025; Fu et al., 2024; Hagen, 2025; Moleman and Kroesen, 2025; Parga et al., 2024; Zhu et al., 2024). Others focused on rating the ease or suitability of reaching daily activities using a specific-mode (Kim, 2024; Negm and El-Geneidy, 2025; Nguyen-Phuoc et al., 2025). However, we argue that perceived accessibility is inherently both mode-specific and destination-specific. It is crucial to select destinations that align with the research question. For example, De Vos et al. (2025) assess perceived accessibility by asking participants about the ease of accessing a university campus in general and by public transit. This approach can help in examining important factors such as travel mode choice to campus. Meanwhile, Mehdizadeh and Kroesen (2025) use statements such as "my neighborhood is easily accessible by [transport mode]" to assess perceived accessibility. This measure is harder to utilize as it focuses on accessibility to the neighborhood rather than from it, making it less compatible with the conventional measures and definitions of accessibility that emphasize access to desired destinations.

Vafeiadis and Elldér (2024a) address these points by asking the participants to rate the ease of performing a specific trip using a specific mode during a specific time period. They rate this aspect for each combination of trip purpose (work, grocery shopping, going to dinner, meeting a friend in the city center) and transportation mode (car, bicycle, public transport, walk). Except for going to the city center, the authors ensured that the participants had performed a trip to the destination in the last month, and the questions were formulated in the past tense. Vafeiadis (2024) uses the same question format and adds another purpose, visiting a cafe/restaurant during the day (lunch). The questions are only asked if a certain mode is available to the participants as cars and bicycles are sometimes unavailable. While this scale is mode- and destination- specific and captures the core aspects of accessibility, we argue that everyone has perceptions to all destinations and by all modes even if they do not perform that trip. And despite past experiences influencing perceived accessibility, restricting the scale to these experiences can hinder the understanding of perceptions.

Studying perceptions is an important tool to understand the differences between people and how they interpret the same physical world differently. To accurately assess perceived accessibility in relation to measures of the built environment and other socio-economic outcomes, it must be clearly defined and not conflated with broader concepts such as well-being. This clarity is essential for designing specific survey instruments that effectively capture the intended information. Current instruments have made progress in validating their questions and ensuring they measure what they are designed for, but uncertainties remain as the next section reviewing empirical findings from these instruments will show.

4.3. Determinants and impacts of perceived accessibility

This section explores the determinants and impacts of perceived accessibility as discussed in the reviewed articles. We cluster the findings into three subsections: (1) individual characteristics, including age, gender, household composition, vehicle ownership, and travel attitude; (2) travel behaviour; and (3) public transport service quality. We acknowledge that additional determinants and impacts remain unexplored, which will be addressed in section 5.

4.3.1. Individual characteristics

Despite some of the uncertainty of some measures' validity, this section reports on the findings of the reviewed articles on socioeconomic impacts on perceived accessibility. The two most explored sociodemographic characteristics were age and gender. Meanwhile, household composition, income, employment status, car ownership, and disability gained less attention.

The impact of age on perceived accessibility is inconsistent. Some studies found no impact (Fu et al., 2024; Lättman et al., 2018; Tanimoto and Hanibuchi, 2021). Others reported positive impact (El Murr et al., 2023; Friman et al., 2020b), negative impact (Liu et al., 2021; Vafeiadis and Elldér, 2024a; van der Vlugt et al., 2019), or non-linear impact (Lättman et al., 2016a; Pot et al., 2023b). Multiple reasons could cause this discrepancy in findings. In some instances, the methods used do not consider potential confounding effects. For example, some authors use an analysis of variance (Lättman et al., 2018), cluster analysis (Lättman et al., 2016a), or comparison of means (Lättman et al., 2019) for age and perceived accessibility instead of using regression analysis. These methods do not consider multiple factors and isolate the impact of each variable, which does not provide conclusive or sufficient results for correct interpretation. In other instances, researchers examine access to specific destinations, such as parks (El Murr et al., 2023), rendering such findings ungeneralizable for other destinations.

Some findings were region-specific, where age had no impact in bigger cities and a negative impact in minor cities (Olsson et al., 2021). Others were concerned with only a certain period, such as during the COVID-19 pandemic where older adults were found to be more likely to suffer from a low level of perceived accessibility and transport equity (Liu et al., 2021). Pot et al. (2023b) explored the possibility of non-linearity, and they found that perceived accessibility increases with age with a peak at 52, and then starts to decrease in rural areas of the Netherlands, which they explained with the notion of willingness and ability to travel. This stresses the importance of considering location, mode of travel, time of study, and travel mode when exploring the impact of age on perceived accessibility.

There is near consensus on the impact of gender on perceived accessibility. Women were found to experience higher levels of perceived accessibility in most of the studies (Friman et al., 2020b; Lättman et al., 2018; Lättman et al., 2019; Olsson et al., 2021; Pot et al., 2023b). Relatedly, Wolday and Böcker (2023) found that women experienced a greater decline in perceived accessibility during the pandemic. Fu et al. (2024) argue that women have higher perceptions of accessibility to specific destinations, but that gender does not impact general perceived accessibility or perceptions of transport-related disadvantage. Meanwhile, Lättman et al. (2016a), van der Vlugt et al. (2019), and Sukhov et al. (2023) found that gender does not impact perceived accessibility, with the latter only studying older adults. Similarly, Vafeiadis and Elldér (2024a) found that gender is not statistically significant for perceived accessibility to different destinations by various modes in most cases. However, they found that women have higher perceived accessibility in specific cases such as by bicycle for commuting or by public transport for grocery shopping. Similar to the case of age, studies need to consider all socioeconomic aspects together and use the suitable variables in their models to correctly estimate this impact. Additionally, future studies should explore the reasons for such difference in perception, especially as the reviewed ones could only speculate about differential gender results (e.g. by linking it to cognitive adaptation to more challenging travel patterns).

Only two studies looked at the possible impact of household composition and found no persistent link to perceived accessibility (Tanimoto and Hanibuchi, 2021), except for an overrepresentation of single-parent households in the lowest quantiles in rural areas (Pot et al., 2023b). Income was generally found insignificant to perceived accessibility (Lättman et al., 2018; Pot et al., 2023b; Tanimoto and Hanibuchi, 2021; Vafeiadis and Elldér, 2024a). In some cases, this result was due to income's effect being mediated by car ownership (Pot et al., 2023b). In a

specific case of accessibility to parks, El Murr et al. (2023) found that the lower-income population reported a lower level of accessibility to this destination. Categorizing income levels is a crucial step as insignificant results could arise due to binary and/or unclear categorization without proper justification. Car availability/ownership positively impacts perceived accessibility (Pot et al., 2023b; Vafeiadis and Elldér, 2024a; van der Vlugt et al., 2019). Pot et al. (2023b) found that, in addition to car ownership, e-bikes-ownership has a significant positive impact on perceived accessibility in rural areas. While it increases perceived accessibility in general, car ownership negatively relates to perceived accessibility by public transport (Olsson et al., 2021; Vafeiadis and Elldér, 2024a). These results could arise from car users not understanding or considering the potential of public transit to help them reach their destinations.

Retirement, compared to employment, was positively associated with perceived accessibility due to experiencing fewer temporal accessibility barriers (Fu et al., 2024; Olsson et al., 2021). When compared with unemployment, people who are retired, self-employed, or employed tend to have higher perceived accessibility levels (Pot et al., 2023b), which could be due to having better financial abilities to reach desired destinations or constantly accessing and noticing a wider range of destinations that improves spatial knowledge. The only survey that examined physical disability found that it negatively impacts perceived accessibility in both urban and rural areas (Pot et al., 2023b). Related to the notion of expanding temporary spatial knowledge and the role of ICT in perception, digital fluency and having access to the internet was associated with higher levels of perceived accessibility (Pot et al., 2023b) and perceived transport equity (Fu et al., 2024; Liu et al., 2021). This is because it allows individuals to retrieve trip information and adjust plans, or virtually access a wider variety of destinations (e.g. grocery stores that are rather inaccessible by public transport). Finally, for social interaction and bonds, having a social network that can help with transportation was found positively related to perceived accessibility (Pot et al., 2023b), explaining how social cohesion has a positive correlation with perceived accessibility (Tanimoto and Hanibuchi, 2021).

The reviewed articles had minimal discussion on travel attitudes and satisfaction. van der Vlugt et al. (2019) found that a better perception of accessibility is formed by a favourable attitude towards public transport. Conversely, Pot et al. (2023b) argue that this is the case for walking, cycling and car use but not public transit and that the skill of using public transit (e.g., understanding information and knowing how to use online trip planners) is what positively impacts perceived accessibility. Related to intentions of travel by certain modes, people in the motivation stage of using public transit in the transtheoretical model (TTM) were found to have a more positive perception of accessibility than those in the volitional stage (Warner et al., 2021). Similarly, good perceived accessibility by public transit was also related to the behavioural intention to use it (Sheng and Zhang, 2022); however, it was not clear how this intention was calculated in that study. Related to that notion, Nguyen-Phuoc et al. (2025) found that positive perceived accessibility by a newly built urban train system positively impacts the intention to use it once operational, highlighting the potential role of perceived accessibility in shaping future travel behaviour.

The impact of socioeconomic characteristics on perceived regional accessibility remains inconclusive. Further research should use data from representable samples that adequately reflect diverse population characteristics. Analysis methods should take into account all possible confounding factors. In-depth analysis of specific populations can provide insights into the components that impact their perceived accessibility based on their particular needs. Understanding how populations perceive accessibility based on their different socioeconomic characteristics can help practitioners and policymakers identify their target groups and design appropriate policies for each.

4.3.2. Travel behaviour

The link between perceived accessibility and travel behaviour remains underexplored in the literature with some findings that would need further elaboration. Many studies employed a variable reflecting the frequency of use of a certain mode. In many instances, this variable was either ill-defined (e.g., no explanation on how it was calculated), or too general [e.g., using a car more than once a week was considered a frequent user, a 5-point scale with daily/always and never on the two ends (Friman et al., 2020b; Olsson et al., 2021), a 3-point scale with unjustified breaks]. In more recent studies, the measure for travel behaviour is more accurate. Mehdizadeh and Kroesen (2025) use a six-point Likert- scale ranging from never, 1 to 5 days per year, 6 to 11 days per year, 1 to 3 days per month, 1 to 3 days per week, 4 or more days per week. And Negm and El-Geneidy (2025) provide the most detailed measure of travel behaviour, using the percentage of weekly public transit trips for five different travel purposes.

Overall, there is little consistency in the results concerning travel behaviour and perceived accessibility. Lättman et al. (2016a) found that the frequency of use of public transport positively relates to perceived accessibility with that mode. However, their study only includes bus users and does not account for socioeconomic differences. Conversely, two studies found that the frequency of use of public transport is negatively associated with perceived accessibility by that mode (Friman et al., 2020b; Olsson et al., 2021). This result could be considered counterintuitive as users of a specific mode would understand the potential of access by this mode more than people who use it less. While all three studies use SEM analysis, they only consider the impact of transit/car usage frequency on public transit and not the opposite direction. Neither consider that perceived accessibility could have an impact on travel behaviour and that decisions to use transit or car frequently could arise from how an individual perceives their accessibility using these modes. Similarly, Andersson et al. (2023) found that the overall perceived accessibility for the sample decreased with the increased number of transit users after a free public transport card intervention. However, this is not a conclusive result on the impact of transit use on perceived accessibility as they do not use panel data that examines perceived accessibility for the same individual.

Some studies simply examined the perceived accessibility for different mode users, or in situations where a certain mode user would be restricted from its use. For example, Lättman et al. (2018) found that bicycle users have the highest levels of perceived accessibility compared to car and public transit users through a comparison of means. By evaluating the PAC for car users if restricted from driving, Lättman et al. (2020) and Tanimoto and Hanibuchi (2021) found that these users' perceived accessibility would significantly decrease if they were restricted from car use. However, both studies did not use panel data from the same individuals to examine such an effect and rather relied on a hypothetical situation, making their results less definitive. Fu et al. (2024) found that multimodal individuals that have limited access to cars have lower perceived accessibility and higher perception of perceived travel-related disadvantages (spending more money on travel than affordable and more time than desired).

Based on ordinal regression analysis, Vafeiadis and Elldér (2024a) argue that frequent car users have high levels of perceived accessibility by car and low levels by all other modes. For four different destinations, they found the same pattern for other modes where individuals tend to have the highest perceived accessibility by the mode they use most. These preliminary results confirm that car users tend to have higher perceived accessibility in general. Negm and El-Geneidy (2025) used regression analysis to examine the impact of perceived accessibility on travel behaviour while accounting for calculated accessibility, residential selection, travel identity, and individual characteristics. They found that positive perceived accessibility by public transit increases weekly public transit mode share. Both studies acknowledge that their cross-sectional data is limited in terms of inferring causal relationships between perceived accessibility and travel behaviour and recommend the

use of panel data in future research.

Using panel data and conducting cross-lagged panel models, Mehdizadeh and Kroesen (2025) find that the relationship between perceived accessibility and travel behaviour is bidirectional. However, they argue that travel behaviour has a stronger influence on perceived accessibility than the reverse effect. It is important to note that this study uses a measure of perceived accessibility that focuses on "accessibility to the neighborhood" (as described in section 4.2), which may overlook how travel behaviour is shaped by the various destinations that people seek to reach by different transport modes.

There is still limited research on perceived accessibility by different modes, whether used or unused. Understanding how travel behaviour impacts and is impacted by perceived accessibility is crucial in developing adequate strategies that encourage sustainable travel.

4.3.3. *Public transport service quality*

Regarding the supply-side of accessibility, the impact of public transport service quality on perceived accessibility was found to be positive upon examination by five studies using SEM analysis (Friman et al., 2020b; Lättman et al., 2016a; Sukhov et al., 2023; Watthanaklang et al., 2024; Zhu et al., 2024). Functionality (also described as reliability and convenience) is one of the most important contributors to this positive relationship (Friman et al., 2020b; Lättman et al., 2016a; Sukhov et al., 2023). This aspect includes reasonable travel times, reliability, frequency, ease of transfers, ease of buying tickets and closeness to the nearest public transport stop. While Sukhov et al. (2023) found functionality not to be a significant determinant for perceived accessibility among older adults, they used necessary condition analysis (NCA) to discover that functionality is a necessary condition for high perceived accessibility for this population group.

Courtesy as a component of responsiveness was also found to be one of the strongest contributors to this relationship, stressing the importance of the staff being ready to assist passengers (Lättman et al., 2016a; Watthanaklang et al., 2024). Comfort was also found to be a significant factor in the positive relationship between quality service and perceived accessibility (Friman et al., 2020b; Sukhov et al., 2023). While Lättman et al. (2016a) found perceived safety on public transport to positively impact perceived accessibility, Olsson et al. (2021) and Sukhov et al. (2023) found it to be insignificant; however, necessary for high perceived accessibility (Sukhov et al., 2023). Cost, however, was found either insignificant or the least important factor in formulating positive (or negative) perceived accessibility. This relates to the idea that income was not found significant in other studies (Lättman et al., 2018; Pot et al., 2023b; Tanimoto and Hanibuchi, 2021). An explanation could be the impact of adaptive preference (Baber, 2007), where people with restricted (financial) capabilities adapt their expectations and preferences to align with their circumstances. This adjustment can result in them downplaying the importance of cost when self-reporting their preferences.

4.4. *(Mis)match between calculated and perceived accessibility measures*

A few studies examined the potential (mis)match between calculated and perceived accessibility measures (El Murr et al., 2023; Lättman et al., 2018; Pot et al., 2023a, 2023b; Vafeiadis and Elldér, 2024a, 2024b). Pot et al. (2021) argue that mismatches between calculated accessibility measures based on spatial data and perceived accessibility arise either from inaccuracies in an individual's spatial awareness or from errors in the calculated measures, particularly in how personal evaluations known spatial accessibility components (e.g. transport system characteristics) are incorporated. This means that despite high levels of calculated accessibility, an individual can still perceive a low level of accessibility because they either lack complete spatial knowledge of their surroundings (inaccuracies in awareness), or because the calculated measure does not account for certain components that are essential to their experience (inaccuracies in measure). Similarly, low levels of calculated accessibility can coincide with high levels of perceived accessibility, depending on the measure's match with individual needs and abilities.

Pot et al. (2023a, 2023b) compared gravity-based accessibility measures for a range of services, including supermarkets, education, healthcare, retail, cultural, hospitality and sporting facilities, with self-reported perceived accessibility using PAC. In both studies, they found that perceived accessibility is more evenly distributed than calculated accessibility in both urban and rural settings, meaning that there generally is a discrepancy between the two measures. Similarly, Lättman et al. (2018) compared data from the PAC with calculated accessibility-indices that include eight indicators that consider travel time and distances to certain destinations and public transport. They also found a mismatch between the two measures, with perceived accessibility being more evenly distributed across residential areas. This phenomenon can be attributed to diminishing returns to a higher number of opportunities and spatial heterogeneity in needs and abilities due to residential self-selection (Pot et al., 2023b). This suggests that people living in rural areas (lower spatial accessibility) on average are less sensitive to spatial accessibility, as they choose to live in an area where they know there are fewer opportunities or have adapted their activity and travel preferences over time. Accordingly, they use other methods (e.g. driving) to compensate for the lack of "measured" locally available opportunities. This was also relevant when Lättman et al. (2020) found that there are significant differences in perceived accessibility when restricted to sustainable modes of travel depending on the area of residence.

Some studies limited the comparison between calculated and perceived measures to certain destinations such as parks (El Murr et al., 2023) and grocery stores (Vafeiadis and Elldér, 2024b). While El Murr et al. (2023) found a misalignment between the number of accessible parks using cumulative opportunities measures and the self-reported accessibility (negative relationship), they found the quality index for parks and the self-reported accessibility to be positively related. Vafeiadis and Elldér (2024b) found an overestimation of perceived accessible grocery stores within 15 min for cycling and public transport, while an underestimation for car accessibility.

Vafeiadis and Elldér (2024a) use travel time and number of amenities accessible within a certain travel time (cumulative opportunities) as calculated accessibility indicators and examine the relationship between this indicator and perceived accessibility by different modes and to different destinations. While they find that reaching more grocery stores and restaurants as well as shorter travel time to city center by transit is associated with higher likelihoods of perceiving ease in reaching these destinations by transit, they find a mismatch between the car accessibility indicator and perceived accessibility by car. As previously discussed, they argue that residential self-selection could be one of the causes of this mismatch, but they also add that it could be due to the accessibility indicator not correctly capturing the accessibility levels by not accounting for parking and congestion. As Vafeiadis (2024) argues, the calculations for the accessibility indicators could have a major impact on the mismatch between calculated and perceived measures, especially if they are too simple.

These findings stress the importance of considering the modes and destinations in the calculated measures. Ensuring the use of well-established calculated measures rather than ill-described secondary indexes could help pinpoint the inaccuracies of measurement. Additionally, to take the analysis a step further into practice and policy formulation, it is necessary to understand how perceived accessibility relates to certain modes and specific destinations. These understandings not only help direct the needed interventions to address the problems that could be causing transport disadvantages, but they also allow for a deeper investigation of other aspects impacting the mismatches, such as the quality of destinations (El Murr et al., 2023).

5. Perceived accessibility conceptual framework

Through the above literature review of perceived regional accessibility, we find that the concept needs a clear definition that captures the core aspects of accessibility and perception at the personal level. As an outcome of the interaction of land use and transport system with individual characteristics, perceived accessibility can be defined as the ***perception of how easily one can access their desired destinations using a (range of) specific mode(s)***. This definition stems from the original definition of accessibility (Dalvi and Martin, 1976; Handy, 1992; Hansen, 1959; Levinson and Wu, 2020) and recent works that measure perceived accessibility (Vafeiadis and Elldér, 2024a).

To pave the way for future research on perceived accessibility, we summarize its potential empirical relationships with calculated accessibility, residential choice, demographics and personal resources, and travel experience and attitudes based on our new definition and how it connects to travel behaviour in Fig. 2. This framework is designed based on the reviewed studies in addition to conceptual studies (Pot et al., 2021; van Wee, 2022). It also draws inspiration from works that conceptualize and explore perceived walkability (De Vos et al., 2023; van der Vlugt et al., 2022).

Calculated accessibility results from the interaction between land-use and transport systems. These spatiotemporal components include the location of opportunities, activity types, the opening hours of destinations, travel mode, transit schedules (if the mode is public transit), road infrastructure, and travel time. Calculated accessibility also considers individual factors, such as basing the calculations on a reasonable travel time threshold, which can be derived from origin-destinations surveys. We argue that these spatiotemporal components in conjunction with individual needs, abilities, travel experiences, and attitudes impact how an individual perceives one's level of accessibility. Previous research has highlighted how calculated accessibility relates to travel behaviour (Moniruzzaman and Páez, 2012; Negm and El-Geneidy, 2024; Owen and Levinson, 2015; Ton et al., 2020). In reality, one's decision relies on how they perceive the built environment. Therefore, as Morris et al. (1979) stated, perceived accessibility is the actual basis of behaviour.

Perceived accessibility, thus, moderates the link between travel needs, experiences, and attitudes and travel behaviour from a certain residential location with a certain spatial accessibility level. An individual's attitude towards a mode may influence the perception of accessibility through this mode, which in turn affects their decision to use it. For example, a person with a positive attitude towards transit and a readiness to use it would likely know the destinations they can reach by transit, unlike someone in the same area with a negative attitude towards transit. An individual weighs their accessibility options based on mode availability, the transport system schedule, the travel time necessary, and the quality of the transport system. Therefore, the availability of the resources themselves, in conjunction with individual needs, desires, experiences, and attitudes, play an important role in the perception of accessibility.

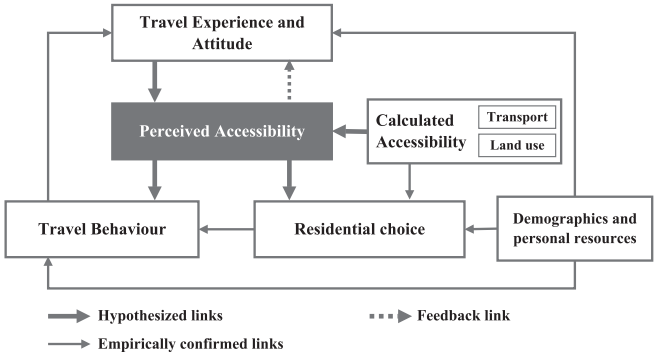

Fig. 2. Framework for empirical research on perceived accessibility.

Travel attitudes are related to personal needs and abilities and can be assessed by demographics (e.g., age, gender, household composition, education level, and income level) and personal resources (e.g., vehicle ownership) but may also vary within groups with similar sociodemographic characteristics. Combined, these factors are major determinants of residential location choice (Buehler, 2011; Patterson et al., 2005; Scheiner, 2014). While research shows that people self-select into residences in areas that fit their attitudes (Handy et al., 2006), we hypothesize that this process is rather driven by perceived accessibility (Pot et al., 2023a). An individual with a positive attitude towards transit would not simply reside near a bus or metro stop. They will weigh the ease with which they can access their desired destinations and choose their residence based on this perception of accessibility. As discussed in section 4.3.3, it is important to take the phenomenon of adaptive preference into account when examining the impact of travel attitudes and demographics on perceived accessibility. People may adjust their preferences to their living circumstances, which in turn impacts their perceived accessibility. This phenomenon can best be examined in longitudinal studies where tracking the same individuals overtime can provide insights into how they adapt their perceptions and behaviours to different circumstances. For example, when a car-dependent individual with low perception of public transit accessibility moves to an area with limited parking and reliable public transit, they may shift their preference overtime to using transit, possibly increasing their perceived accessibility by that mode. Therefore, this adaption process influences how individuals perceive accessibility, as their preferences and attitudes adjust in response to changes in their lifestyle and surroundings.

As one travels using a certain mode, they develop experiences that can change or reinforce their attitudes or satisfaction towards that mode (De Vos et al., 2016; De Vos et al., 2022; Ye and Titheridge, 2017). A person with a positive transit experience and knowledge of how it works is more likely to see it as an easy way to reach their desired destinations. These experiences and attitudes are impacted by previous travel behaviour (Kroesen et al., 2017). In a broader context, future studies could explore the link between perceived accessibility and both travel and life satisfaction, given that travel satisfaction can have a long-term impact on overall life satisfaction (De Vos and Witlox, 2017). In our literature review, one study that examined this relationship for older adults in five European cities found that perceived accessibility has a positive impact on overall life satisfaction (Lättman et al., 2019). Another study on older adults in the Republic of Korea found similar results (Kim, 2024). As some of the relationships in this model still need investigation and validation in different contexts for various population groups, we recommend areas and methods for future research in the following section.

6. Recommendations for future research

Based on examining the current state of research in perceived regional accessibility and the conceptual framework in Fig. 2, this section highlights key areas for future research.

- Utilizing panel data (data that examines the same individuals overtime) is essential to unravel the direction of the relationships in the conceptual model, such as:
  - o The impact of perceived accessibility on travel behaviour and residential choice.
  - o The influence of calculated accessibility on perceived accessibility.
  - o The role of travel behaviour in shaping perceived accessibility, mediated by travel experience and attitudes.
- Utilizing mediation analysis within the framework of structural equation modelling could prove useful in unravelling the relationships between the different components and impacts of perceived accessibility.

- Based on the findings from the examined research, we recommend deeper examination on the impacts of sociodemographic characteristics on perceived accessibility, understanding how different population groups experience and interpret accessibility.
- Future research could investigate the (mis)match between calculated and perceived accessibility measures across different contexts and populations, with a focus on understanding the reasons behind such mismatches.

Below we provide recommendations on data collection, measures, and methodology.

- Clearly defining perceived accessibility in the context of the research is crucial for properly positioning it within the literature.
- Ensuring the measurement consistency with the definition is important. The measure would ideally be destination- and mode-specific, using a Likert Scale to capture nuances in perception.
- Comprehensive data collection should include all the potential factors related to perceived accessibility, including but not limited to travel behaviour, travel attitude, residential location, self-selection, sociodemographic, and perceived accessibility itself.

7. Conclusion

In this article, we review 45 articles that examine perceived regional accessibility. We find that empirical work on the topic is emerging but significant ambiguities surrounding its definition and measurement remain. Definitions of perceived accessibility tend to conflate with broader notions of well-being, which hampers the unambiguous interpretation of empirical findings regarding how perceived accessibility can be explained and connected with travel behaviour and socioeconomic characteristics. Drawing from the conventional definition for accessibility and from the reviewed studies, we define perceived accessibility as ***the perception of how easily one can access their desired destinations using a (range of) specific mode(s)***. Accordingly, we propose a conceptual model that identifies the potential determinants and impacts of perceived accessibility, suggesting pathways for future studies to integrate this concept more effectively.

Accounting for perceptions in accessibility evaluations can appear complex. However, it is important to remember that there is no such thing as 'objective' accessibility, as an individual's decisions are mediated by their needs, desires, and abilities (Pot et al., 2021). Empirical research on perceived accessibility can inform accessibility evaluations in practice through examining how different populations experience their various calculated accessibility levels based on their socioeconomic characteristics. However for this to work, it is crucial to ensure that future measures remain technically feasible, operationally transparent, and yield easily interpretable results (Morris et al., 1979).

As accessibility becomes more integral to transport planning, understanding its meaning to people and how they perceive it is essential for professionals and decision-makers. Exploring how perceived accessibility affects individuals' decisions will help develop strategies that ensure equitable access to opportunities and encourage sustainable behaviour. Rather than focusing solely on expanding infrastructure to improve accessibility and boost public transit use, highlighting areas where there is a mismatch between calculated and perceived accessibility levels can help develop policies ensuring that people are aware of the available transport options to them, increasing their perceived accessibility. Policymakers can aim to promote real-time transit data and digital wayfinding tools around these areas with mismatch, to better communicate the reliability and accessibility of public transit. Additionally, analyzing the relationship between perceived accessibility, well-being, and life satisfaction across different demographic groups can guide policies that better serve underserved communities. Addressing disparities in perceived accessibility can contribute to a more inclusive transport system, ultimately improving social equity and quality of life.

Author contribution

The authors confirm contribution to the paper as follows: Study conception and design: Negm, De Vos, Pot, & El-Geneidy; Data collection: Negm & El-Geneidy; Analysis and interpretation of results: Negm, De Vos, Pot & El-Geneidy; Draft manuscript preparation: Negm, De Vos, Pot, & El-Geneidy. All authors reviewed the results and approved the final version of the manuscript.

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Data availability

No data was used for the research described in the article.

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